# A Method of Backgrinding Wafers while Leaving Backgrinding Tape on a Chuck

This application is a continuation-in-part of U.S. Application 10/315,746, filed December 10, 2002, which is a continuation of U.S. Application 10/259,536, filed September 26, 2002, now U.S. Patent 6,638,389, which is a continuation-in-part of U.S. Application 09/675,747, filed September 27, 2000.

## Field of the Inventions

The present invention is in the field of semiconductor manufacturing and it specifically relates to devices and methods for protecting the front side of device wafers during backgrinding, grinding, polishing, or chemical mechanical planarizing of very thin and frangible wafers.

## Background of the Inventions

As described in U.S. Patent No. 5,476,566 issued December 19, 1995 to Cavasin, semiconductor wafers are typically sawn to approximately a 30 mil (0.76 millimeter) thickness as they are being manufactured. Thereafter, electronic circuitry is formed on one side of the wafer, called the front or active side. The front side of the wafer is planarized at various stages of electronic circuit formation, usually by a process known as chemical mechanical planarization (CMP). The wafers may then be thinned in subsequent processing by a backgrinding process wherein the backside, i.e., the side not covered by circuit components, is ground until the wafer is of a reduced thickness, typically on the order of 14 mils (0.36 millimeter). Advances

in device packaging have led to a demand for very thin wafers, on the order of 8 mil (0.20 millimeter) in thickness.

Unfortunately, the ongoing demand for thinner wafers has been accompanied by an ongoing demand for larger-diameter wafers. Wafers having a nominal diameter of 200 millimeters (about 8.0 inches) are replacing wafers nominally 6.0 inches (actually 150 millimeters) in diameter. As a result of these converging trends, breakage of the wafers during processing has become a serious problem. If the breakage occurs after a number of process steps have been performed on the wafer, the result can be costly, thereby undermining the benefits gained by using larger diameter wafers. Thus, the forces applied to the wafers in the backgrinding process must be applied uniformly across the wafer to minimize breakage.

The problem is further aggravated by the delicate nature of the circuitry built up on the active front surface of the wafer, which ideally should not be scratched by sliding under the pressure applied by a chuck during the backgrinding process. To protect the wafer against this eventuality, it is known in the art (U.S. Patent No. 5,476,566) to apply an adhesive tape to the front surface of the wafer to protect the circuitry while the backside of the wafer is being ground to achieve a reduced thickness.

In U.S. Patent No. 5,964,646 issued October 12, 1999 to Kassir et al. there is described the advantageous use of a resilient pad between the wafer and the chuck that supports the wafer during the grinding process. The use of the resilient pad is found to improve the flatness of the ground surface.

The present invention builds on this earlier work by providing a tool that facilitates installing a resilient tape on

the chuck, rather than on the front side of the wafer. This permits the resilient tape to remain in place while a number of wafers are ground, polished, or planarized in succession, and this is much more efficient than the prior art technique of applying a resilient tape to each wafer.

Several circumstances complicate the apparently simple operation of applying an adhesive tape to the chuck that is used to hold the wafer during grinding, polishing, or planarization.

First, a widely used type of chuck is composed of an open cell porous ceramic, which allows the wafer to be held against the chuck by a vacuum applied through the ceramic material. As grinding progresses, grinding dust tends to be pulled into the pores of the ceramic chuck. These dust particles can come into contact with the device side of subsequent wafers, causing damage. Therefore, to protect wafers later processed on the same chuck, the dust is usually removed from the chuck after each wafer has been ground. The dust is typically removed by backflushing, whereby water is forced through the porous ceramic chuck in a direction opposite the vacuum airflow. Backflushing would tend to remove the tape from the chuck, but if the adhesion of the tape were great enough to withstand the water pressure, then backflushing could not take place.

A second problem encountered in applying a tape to the chuck is that the tape would tend to seal the ceramic material, defeating the vacuum that is relied on for holding the wafer to the chuck.

A third problem that the present inventors needed to solve was preventing air from becoming trapped between the tape and the chuck. Air bubbles trapped between the tape and the chuck caused the tape to be not completely flush against the chuck,

and so the tape was not uniformly flat. Thus, the wafer resting on the tape would be more prone to defects after backgrinding, polishing, or CMP processes were performed.

## Summary

The approach taken by the present inventors is to replace the porous ceramic chuck with a solid chuck having passages through it to permit the vacuum to be applied to the wafer. They then use a tape having apertures that register with the ends of the passages at the face of the chuck. To prevent air from being trapped between the tape and the solid chuck, the tape is applied to the chuck in a vacuum. To facilitate applying the tape to the chuck, the inventors developed a specialized tool that permits the operation to be accomplished swiftly and flawlessly.

In accordance with a preferred embodiment of the invention, a removable vacuum chamber fits over and sealingly engages the chuck. The removable vacuum chamber is indexed to the chuck by means of locating pins. Within the removable vacuum chamber a stamp is provided that is movable in a direction perpendicular to the face of the chuck. The tape to be applied is indexed to the face of the stamp, and then the stamp is advanced toward the chuck to bring the tape into adhesive contact with the face of the chuck. The absence of air within the chamber eliminates the possibility of air being trapped between the tape and the face of the chuck. After the tape has been applied to the chuck, the stamp is retracted, the vacuum within the chamber is relieved, and the chamber is removed from the chuck, leaving the chuck ready to receive a disc.

A method of backgrinding multiple wafers without applying backgrinding tape to the wafers is also presented. Tape is

applied to the chuck, instead, and a wafer is placed on the tape just prior to backgrinding. After backgrinding the wafer, the front side and backside of the wafer are thoroughly rinsed and scrubbed to remove any particulates. Successive wafers are similarly background and cleaned while using the same piece of tape. The tape on the chuck is replaced when the tape becomes exhausted.

The novel features which are believed to be characteristic of the invention, both as to its structure and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the invention.

## Brief Description of The Drawings

FIG. 1 shows a first preferred embodiment of the tool of the present invention.

FIG. 2 shows an alternative embodiment of the present invention.

FIG. 3 illustrates a chuck provided with blind registration holes and a tool for applying tape to the chuck.

FIG. 4 illustrates a porous chuck and a tool for applying porous tape to the chuck.

FIG. 5 is a block diagram of a system for producing integrated chips, including the backgrinding step.

FIG. 6 is a block diagram of a method of backgrinding wafers.

## Detailed Description of the Inventions

Figure 1 shows a first preferred embodiment of the tool of the present invention. The chuck **12** is composed of a non-porous rigid material such as a non-porous ceramic. The chuck is provided with a number of passages, of which the passage **14** is typical, that extend completely through the chuck and that are manifest as holes in the face **16** of the chuck. When a wafer is being background, the front surface of the wafer faces the face **16** of the chuck. On the opposite side **18** of the chuck is a chamber **20** that can be selectively evacuated by connecting a vacuum pump to the port **22**.

In accordance with the present invention, a tool is used for applying an insert **34** to the face **16** of the chuck. The insert **34** may comprise tape, a pad, a disk, or other device suitable for supporting a wafer on the chuck or wafer carrier. The insert may have an adhesive on one side, both sides, or neither side. The insert may be porous or may be provided with one or more holes so that a vacuum may communicate from the vacuum chamber **20**, through the chuck, through the insert, and to the wafer.

In a preferred embodiment, the tool includes a removable housing **24** that, when placed over the chuck in sealing engagement forms a closed chamber **26** that is evacuated when a vacuum pump is connected to the port **22**; air initially within the chamber **26** is drawn through the passages **14** into the chamber **20** and out through the port **22**.

Within the chamber **26**, a stamp **28** faces the face **16** of the chuck. The stamp **28** includes a planar face **30** that is

maintained parallel to the planar face **16** of the chuck as the stamp is advanced toward the chuck. At least two locating pins, of which the pin **32** is typical, protrude from the face **30**. These pins are used as follows.

At the beginning of the procedure, before the removable housing **24** is placed over the chuck **12**, the tape **34** which is to be attached to the face **16** of the chuck is precut to the desired size and shape, including an array of holes that are spaced to register with the passages **14** of the chuck. The precut tape **34** is manually placed on the face **30** of the stamp, and the tape **34** is indexed to the stamp by shifting the tape until the locating pins **32** extend through certain holes in the tape. The side of the tape that faces the chuck bears an adhesive coating. Once this has been done, the removable housing **24** is placed over the chuck **12**.

One or more locating pins, of which the pin **36** is typical, index the removable housing **24** with respect to the chuck **12**. A vacuum is then applied at the port **22**, and after the chambers **20** and **26** are sufficiently evacuated, the stamp **28** is advanced toward the chuck **12**. As the face **30** closely approaches the face **16** of the chuck, the locating pins **32** advance into the passages **14**, thereby improving the accuracy with which the holes in the tape **34** register with the passages **14** of the chuck.

The adhesive coating on the exposed side of the tape or insert **34** adheres the tape or insert to the face **16** of the chuck. The lack of air in the chamber prevents air from being trapped between the tape or insert and the face of the chuck.

A number of possibilities exist for the design of the stamp and there are a number of ways of moving it toward the chuck. For example, in the preferred embodiment the face **30** of the

stamp includes a layer **38** of a resilient material (through which the locating pins **32** extend) to assure a uniform distribution of pressure when the film is pressed against the face **16** of the chuck. In one alternative embodiment, a weaker adhesive on the side of the tape facing the stamp suffices to retain the tape on the stamp before the tape makes contact with the face **16**. Any traces of this weak adhesive remaining on the tape after the tape has been applied to the chuck may be removed by a suitable solvent.

In another alternative embodiment, the tape is drawn against the stamp by a vacuum applied through the stamp. This can be done by using either a porous stamp or a non-porous stamp having passages through it, analogous to the manner in which the chuck **12** retains a wafer. Clearly, the pressure in the chamber **26** must be controlled to be slightly greater than the pressure at the face **30** of the stamp, until the tape has made contact with the chuck. Thereafter, a slight overpressure may be applied through the stamp to overcome any tendency of the tape to cling to the face of the stamp.

Consistent with the present invention, any of several techniques may be used to advance the stamp. In the preferred embodiment of Figure 1, the stamp is pushed manually into the housing **24**. In alternative embodiments, the integrity of the removable housing is not disturbed, and the moving mechanism is located entirely within the chamber **26**.

For example, in the alternative embodiment shown in Figure 2, an air-filled bellows **40** located above the stamp expands as the vacuum is applied to the port **22**, so as to push the stamp toward the chuck. When the vacuum is relieved, the bellows returns to its original smaller size. The action of the bellows repeats automatically each time the vacuum is applied, and the

use of the bellows eliminates the need for electrical or vacuum feed-through on the housing **24**. In still other embodiments, the stamp could be driven by an electrical solenoid or motor.

Figure 3 illustrates a chuck provided with blind registration holes and a tool for applying tape to the chuck. The chuck in this embodiment is porous. A number of blind holes **42** are provided in the top of the chuck, and some or all of these holes are located to correspond to registration pins protruding from the stamping surface of the stamp. The tape is provided with corresponding holes, located such that placing the tape on the stamp with the registration pins protruding through the holes in the tape, and thereafter lowering the stamp so that the registration pins enter corresponding blind holes, properly locates the tape relative to the chuck. The registration pins are sized and dimension to fit within the blind holes of the chuck and permit the stamping face and tape assembly to move into contact with the chuck. When the tape is applied to the chuck, numerous holes in the tape align with numerous holes in the chuck. Thus, registration is achieved as described relative to the previous figures, and the porous chuck can be back-flushed. Thereafter, a wafer can be placed on the tape and secured to the tape by suction applied through the chuck (with a vacuum applied to the bottom of the chuck acting on the wafer through the pores and blind holes of the chuck). Fluid used for backflushing passes partly through the blind holes, and relieves pressure that might otherwise push and lift the tape away from the chuck.

Figure 4 illustrates a porous chuck and a tool for applying porous tape to the chuck. The chuck is porous, or provided with a multitude of through holes. The tape is also highly porous, comprised of a reticulated foam (such that air may pass from one

side to the other through the tape), or provided with a multitude of through holes. The number and size of pores or through holes are chosen such that, regardless of the position of the tape on the chuck, a sufficient number of pores or holes in the tape overly holes or pores on the chuck. The tape is applied to the chuck after evacuation of the vacuum chamber, as described in relation to the previous figures, and is held to the chuck by the adhesive on the chuck side of the tape. Thereafter, a wafer can be placed on the tape and secured to the tape by suction applied through the chuck (with a vacuum applied to the bottom of the chuck).

In another alternative embodiment the chuck is removed from the backgrinding or CMP machine and may be inverted to form the upper end of the chamber **26**. Gravity may then be relied on to keep the tape on the face **30** of the stamp prior to contact of the tape with the face **16** of the chuck.

Thus, there has been described a tool for applying an adhesive-coated tape to the face of a chuck that is used to hold a wafer during grinding, polishing, or CMP operations. The application of an adhesive-coated resilient tape to the face of the chuck is particularly helpful when backgrinding of the wafer is performed, in that the resiliency of the tape prevents the unyielding face of the chuck from damaging the frangible electronic components on the front side of the wafer.

In use, the tool is used to apply an insert to the face of a chuck. A vacuum supplied through the chuck and the insert holds the wafer during one or more methods of grinding or polishing the back surface of a wafer that has circuitry deposited on the front surface without damaging the circuitry. The wafer may be similarly held during various CMP steps.

One method of grinding or polishing the backside of a wafer comprises the steps of adhering a tape (which may be resilient) to the chuck, placing the wafer onto the chuck such that the front surface of the wafer is facing the tape, and then grinding the back surface of the wafer. The tape protects the front side of the wafer from the chuck. A method of performing CMP comprises the steps of adhering a tape to the chuck, placing the wafer onto the chuck, and then performing CMP on the wafer. The tape protects the side of the wafer facing the chuck.

The chuck face may be provided with a pattern of holes and the resilient tape may be provided with a matching pattern of apertures. In this case, an additional initial step may be added to any of the above methods of grinding, polishing, or planarizing a wafer comprising the additional step of positioning the tape so that the apertures in the tape are in registration with the holes in the face of the chuck.

Figure 5 shows a method of making an integrated chip and helps place in context both the tool described herein and the method already described for backgrinding wafers without applying tape to the wafer. In steps **50, 51** and **52** prime wafers are formed by slicing blank wafers from silicon ingots, polishing the sliced wafers and otherwise readying the wafers for the process of building devices on the wafers. (The process of cutting the wafers from an ingot may be referred to as wafering.) In steps **53** and **54**, integrated circuits, MEMS (microelectromechanical) devices or other devices are built onto the front side of the wafer. In step **55** the bulk of the silicon substrate is removed from the backside of the wafer in a process known as backgrinding. Our method of backgrinding wafers without applying tape to the wafer is particularly useful when

building integrated circuits on the wafers because our method allows for backgrinding very thin wafers.

Prior art backgrinding methods follow the steps of applying tape to a wafer, backgrinding the wafer, rinsing the backside of the wafer and removing the tape from the wafer. Our method follows the steps of placing tape onto a chuck, placing the wafer on the tape, backgrinding the wafer, removing the wafer from the tape and rinsing the front side and the backside of the wafer. Prior art methods use separate machines to apply tape to the wafer, to backgrind and rinse the wafer and to remove the tape. Our methods use the same machine to perform all of the steps in our method. The prior art methods and our methods are performed within step **55** of Figure 5. Our method of backgrinding, illustrated in Figure 6 below, also takes place within step **55** of Figure 5.

Turning again to Figure 5, during step **56** the wafer may be processed to relieve stress caused by surface variations on the backside of the wafer. During this step the backside of the wafer is etched. (The processes used to etch the wafer may include spin etching with an acid or dry plasma etching.) The etching process removes areas of stress in the wafer and prevents the wafer from warping. (In our U.S. patent application 10/059,701 filed January 29, 2002, which is hereby incorporated by reference in its entirety, we show a method of relieving stress in a wafer by spin etching with an alkali etchant. We apply an aqueous solution of potassium hydroxide (KOH), or other base or alkali etch solution, to a spinning wafer in a gaseous environment.)

In step **57** a newly etched wafer is rinsed and dried again to ensure that remaining etchant does not damage the wafer or the devices built-up on the wafer. The wafer and devices are

also inspected for unwanted defects. In step **58** the wafer is cut into individual die. Each die is an individual integrated circuit chip, MEMS device or other device. In the case of integrated circuit chips, each die is further processed by attaching wires to wire leads on the integrated circuit chip. In step **59** the new integrated circuit chips are tested again and then encapsulated into ceramic or plastic enclosures.

Figure 6 is a block diagram of a method of backgrinding wafers. The steps illustrated in Figure 6 are performed within backgrinding step **55** of Figure 5. In step **70** tape is firmly secured to the chuck in preparation for backgrinding. The tape may be attached to the chuck with an adhesive. The tape also may be secured to the chuck by first securing the tape to a hoop or frame, and then securing the hoop or frame to the chuck.

In step **71** the wafer is placed on the tape, with the front side of the wafer facing the wafer side of the tape. Afterwards, in step **72**, a machine backgrinds the wafer and removes a precise amount of substrate from the backside of the wafer. When backgrinding is complete, the backside of the wafer is rinsed in step **73** to remove the bulk of remaining silicon particles and other contaminants. Subsequently, the wafer is removed from the tape and chuck in step **74**. The tape remains on the chuck for use with another wafer and the tape is used until exhausted. The tape is replaced after processing about 5 to about 50 wafers.

After the wafer is removed from the tape, the wafer is rinsed again in step **75** to remove unwanted particles that may remain after backgrinding. First, the front side of the wafer is sprayed with high-pressure deionized water, or other suitable cleaning liquid, while the front side is also scrubbed with a suitable brush. The pressure of the spray is in the range of

about 500 PSI to about 1500 PSI, preferably about 800 PSI. Second, the backside of the wafer is washed again with a medium-pressure spray of deionized water, about 40 PSI to about 80 PSI (preferably about 60 PSI), while the backside is also scrubbed with a suitable brush. The order of cleaning can be reversed in some applications.

After the wafer has been cleaned, the entire wafer is dried. Preferably, the wafer is not left to dry on its own (by evaporation), but is actively dried by blow-drying in order to prevent corrosion of integrated circuit elements. The process of cleaning and drying the wafer may be performed in the same machine in which backgrinding is performed. After cleaning and drying, the wafer is transferred to another machine or to another station in the same machine for additional processing. The wafer may be transferred to a machine for performing wafer stress reduction (step **56** in Figure 5) by etching or the wafer may be ready for final inspection (step **57** in Figure 5) or for failure analysis by backside emission microscopy or other failure analysis techniques.

After the first wafer is processed, the front side of a second wafer is placed onto the tape in step **76** and the steps described in reference to the first wafer are repeated on the second wafer. Specifically, the second wafer is background in step **77**, the backside rinsed in step **78** and the second wafer removed from the tape in step **79**. The tape again remains on the chuck after the second wafer is removed. The second wafer then is cleaned in step **80** in the same manner as described in step **75**. The second wafer is then ready for further processing. The process shown in steps **70** through **80** are repeated as often as necessary to backgrind and clean all of the wafers in a batch of wafers.

In the process described in reference to Figure 6, the tape used on the chuck may be replaced with a mesh of material that protects the front side of the wafer during backgrinding. The mesh is a thin sheet of woven polyester, nylon or similar materials. A porous, non-abrasive pad may also be used. The mesh or pad is held in a hoop. The hoop is placed over the chuck and the wafer is placed on the mesh. A series of wafers are then background, with the front side of any given wafer facing the mesh or pad. Each wafer is then cleaned and processed, as described above. Examples of the hoop and mesh arrangement are described in our U.S. Application 10/249,433, filed April 8, 2003, the entirety of which is hereby incorporated by reference.

Because tape is not adhesively applied to the wafers (or not used at all in the case where a mesh is used instead), the backgrinding process described in reference to Figure 6 may be referred to as tapeless backgrinding. Tapeless backgrinding has several advantages over the prior method of backgrinding wafers. Because tape is not placed on each wafer, tapeless backgrinding uses very little backgrinding tape, thereby saving money and increasing overall production efficiency. The process may also save time, depending on the application, to further increase production efficiency. The process also facilitates backgrinding of larger-diameter and thinner wafers, vis-à-vis the prior art process of adhesively applying tape to each wafer and removing the tape from the wafer.

The foregoing detailed description is illustrative of several embodiments of the invention, and it is to be understood that additional embodiments thereof will be obvious to those skilled in the art. The embodiments described herein together

with those additional embodiments are considered to be within the scope of the invention.